<u>Claim(s)</u>

What is claimed is:

1. An apparatus for receiving and storing incoming cells derived from data transmissions conveyed on a network, and for then forwarding the cells elsewhere in the network, the apparatus comprising:

a cell memory for sequentially receiving and storing the incoming cells in separate memory blocks, each of the memory blocks being identified by a unique identification number (BLOCK_ID), and for thereafter reading out a cell stored in any one of the memory blocks when its BLOCK_ID is transmitted to the cell memory;

queuing means (36) for sequentially generating BLOCK_IDs of memory blocks storing cells to be read out of the cell memory; and

memory control means (30) for maintaining a BLOCK_ID queue, for adding BLOCK_IDs generated by the queuing means to the BLOCK_ID queue in an order in which they are generated by the queuing means, and for removing BLOCK_IDs from the BLOCK_ID queue and transmitting them to the cell memory in an order in which the BLOCK_IDs were added to the BLOCK_ID queue such that the cell memory reads out the cells stored in the memory blocks identified by the BLOCK_IDs transmitted by the data path control means

2. The apparatus in accordance with claim 1 further comprising:

first buffer means (37) for storing cells out of the cell memory, and for thereafter reading out and forwarding cells it has stored.

3. The apparatus in accordance with claim 2 wherein the first buffer means produces and sends first back pressure data to the memory control means indicating whether a number of cells stored in the first buffer means is above a first threshold level,

wherein the memory control means successively removes BLOCK_IDs from the BLOCK_ID queue and transmits them to the

cell memory whenever the BLOCK_ID queue contains at least one BLOCK_ID and the first back pressure data indicates that the number of cells stored in the first FIFO buffer means is above the first threshold level, and

wherein the memory control means refrains from removing BLOCK_IDs from the BLOCK_ID queue and transmitting them to the cell memory whenever the first back pressure data indicates that the number of cells stored in the first buffer means is below the first threshold level.

4.   The apparatus in accordance with claim 3 further comprising

second buffer means (24) for storing cells read out of the first buffer means and for thereafter forwarding each cell it stores elsewhere in the network.

5.   The apparatus in accordance with claim 4 wherein the second buffer means generates second back pressure data indicating an amount of unoccupied storage capacity of the second buffer means, and

wherein the first buffer means sets the first threshold level in response to the second back pressure data.

6.   A method for receiving and storing cells derived from data transmissions conveyed on a network, and for then forwarding the cells elsewhere in the network, the method comprising the steps of;

a.   sequentially receiving and writing the cells into separate blocks of a cell memory, wherein each memory block is identified by a unique identification number (BLOCK_ID);

b.   generating a sequence of BLOCK_IDs of memory blocks currently storing cells;

c.   adding each generated BLOCK_ID to a BLOCK_ID queue,

d.   successively removing each BLOCK_ID from the BLOCK_ID queue in an order in which BLOCK_IDs were added to the BLOCK_ID queue whenever the BLOCK_ID queue contains BLOCK_IDs and first back pressure data indicates that BLOCK_IDs may be removed from the BLOCK_ID queue, and

refraining from removing BLOCK_IDs from the BLOCK_ID queue
when the first back pressure data indicates that BLOCK_IDs
may not be removed from the BLOCK_ID queue,

   e.   reading a cell out of the cell memory whenever the
BLOCK_ID of the memory block in which it is stored is removed
from the BLOCK_ID queue at step d.

   7.   The method in accordance with claim 6 further
comprising the steps of:

   f.   writing cells read out of the cell memory into first
buffer means for storing and reading out cells,

   g.   reading the cells out of the first buffer means, and

   h.   setting the first back pressure data to indicate
that BLOCK_IDs may not be removed from the BLOCK_ID queue
whenever a number of cells stored in the first buffer means
rises above a threshold level, and setting the first back
pressure data to indicate that BLOCK_IDs may be removed from
the BLOCK_ID queue whenever the number of cells stored in the
first buffer means falls below the threshold level.

   8.   The method in accordance with claim 7 further
comprising the steps of:

   i.   storing cells read out of the first buffer means in
second buffer means for storing and reading out cells;

   j.   reading cells out of the second buffer means and
forwarding them elsewhere in the network;

   k.   generating a second back pressure data indicating
an amount of unoccupied storage capacity of the second buffer
means; and

   l.   setting the threshold level in response to the value
of the code conveyed in the second back pressure data.

   9.   A method for receiving and storing cells derived
from data transmissions conveyed on a network, and for then
forwarding the cells elsewhere in the network, wherein each
cell is identified as belonging to one of a plurality of
flows, wherein each flow has defined minimum and maximum
forwarding rates, and wherein each flow is assigned to one of

a plurality of virtual output queues (VOQs), the method comprising the steps of;

    a.   sequentially receiving and writing the cells into separate blocks of a cell memory, wherein each memory block is identified by a unique identification number (BLOCK_ID);

    b.   for each flow for which cells identified as belonging thereto are currently stored in the cell memory, generating BLOCK_IDs of memory blocks storing such cells at a rate bounded by that flow's defined minimum and maximum forwarding rates;

    c.   establishing a separate BLOCK_ID queue corresponding to each of the VOQs,

    d.   adding each BLOCK_ID generated at step b to a BLOCK_ID queue corresponding to the VOQ to which is assigned the flow of a cell stored in a memory block identified by the generated BLOCK_ID,

    e.   for each VOQ providing corresponding first back pressure data indicating whether BLOCK_IDs may or may not be removed from the BLOCK_ID queue corresponding to the VOQ;

    f.   for each VOQ, whenever the corresponding first back pressure data indicates BLOCK_IDs may be removed from the corresponding BLOCK_ID queue, successively removing BLOCK_IDs from the corresponding BLOCK_ID queue in an order in which they were added to the BLOCK_ID queue;

    g.   for each VOQ, whenever the corresponding first back pressure data indicates BLOCK_IDs may be not be removed from the corresponding BLOCK_ID queue, refraining from removing BLOCK_IDs from the corresponding BLOCK_ID queue; and

    h.   reading a cell out of the cell memory whenever the BLOCK_ID of the memory block in which the cells is stored is removed from any BLOCK_ID queue at step f.

    10.   The method in accordance with claim 9 further comprising the steps of:

    i.   storing each cell read out of the cell memory in first buffer means,

    j.   reading the cells out of the first buffer means, and

k. for each VOQ, generating the corresponding first back pressure data,

wherein the first back pressure data indicates that BLOCK_IDs may be removed from the BLOCK_ID queue corresponding to the VOQ when a number of cells of flows assigned to that VOQ stored in the first buffer means is below a first threshold level, and

wherein the first back pressure data indicates that BLOCK_IDs may no be removed from the BLOCK_ID queue corresponding to the VOQ when a number of cells of flows assigned to that VOQ stored in the first buffer means is above the first threshold level.

11. The method in accordance with claim 10 further comprising the steps of:

l. storing cells read out of the first buffer means in second buffer means;

m. reading cells out of the second buffer means and forwarding them elsewhere in said network;

n. for each VOQ, generating corresponding second back pressure data indicating an amount of unoccupied storage capacity of the second buffer means, and

o. adjusting the first threshold level corresponding to each VOQ in response to the second back pressure data corresponding to that VOQ.

12. The method in accordance with claim 11 further comprising the step of:

p. for each VOQ, generating a corresponding third back pressure data indicating whether a number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is above or below a second threshold level,

wherein a rate at which BLOCK_IDs of cells identified as belonging to each flow assigned to the VOQ are generated at step g is set to the flow's assigned minimum forwarding rate when the corresponding third back pressure data indicates that the number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is above the second threshold level, and

wherein the rate at which BLOCK_IDs of cells identified as belonging to each flow assigned to the VOQ are generated at step g is set higher than the flow's assigned minimum forwarding rate when the corresponding third back pressure data indicates that the number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is below the second threshold level.

13. The method in accordance with claim 9 further comprising the step of:

i. for each VOQ, generating a corresponding third back pressure data indicating whether a number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is above or below a second threshold level,

wherein a rate at which BLOCK_IDs of cells identified as belonging to each flow assigned to the VOQ are generated at step g is set to the flow's assigned minimum forwarding rate when the corresponding third back pressure data indicates that the number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is above the second threshold level, and

wherein the rate at which BLOCK_IDs of cells identified as belonging to each flow assigned to the VOQ are generated at step g is set higher than the flow's assigned minimum forwarding rate when the corresponding third back pressure data indicates that the number of BLOCK_IDs residing in the corresponding BLOCK_ID queue is below the second threshold level.